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Cyclododecane: practical applications in textile conservation

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Cyclododecane's properties as a temporary consolidant are well known and widely published in various fields of art conservation but it is cyclododecane's properties as a temporary barrier to liquids that make it so useful to the textile conservator. The Victoria and Albert Museum has an extensive collection of textile and costume that is in great demand for exhibition and loan, resulting in the requirement for a considerable amount of aqueous treatment. As a result, we are always looking for ways to expand our selection of conservation techniques. Using various case studies as examples, this paper will discuss the ways in which cyclododecane has been used to facilitate treatments that would have been either impossible or very difficult to do without it. The first case study describes the use of cyclododecane to prevent tideline formation when applying a temporary tissue paper facing to a badly damaged, painted American Civil War flag. The paper then explores the use of cyclododecane as a wet cleaning aid by describing its use to isolate embroidery threads with fugitive dyes during the wet cleaning of an early 18th-century English quilt and a 19th-century Turkish towel. Its use to preserve an ink customs stamp on an early 19th-century printed muslin and as a way of protecting leather from damage during the solvent cleaning of metal decorations on a pair of 19th-century Turkish shoes is discussed. The final case study looks into the use of cyclododecane to form a barrier around an enzyme gel during a suction-table treatment to remove oily stains from an 18th-century silk counterpane. This paper also discusses the practical shortcomings of cyclododecane and why the author chose not to use it when wet cleaning two textiles with water-sensitive decorations.

1 Introduction

I first became aware of cyclododecane (CDD) when contemplating the treatment of a painted silk flag with my colleague Beth Szuhay in 2002. The flag was the regimental colours of the 4th Regiment, Infantry California volunteers, a rare surviving American Civil War flag in the collection of the State Capitol Museum in Sacramento, California. The flag had been previously repaired in 1928 by sewing the silk (and painted areas) onto a linen backing using a coarse ladder stitch. The flag had then been on permanent display in the rotunda of the State Capitol building for over 70 years and was in poor condition. The repair sewing holding the silk to the linen backing also went through areas of painted silk, which had had the effect of perforating and breaking up the paint into thousands of small chips. Our major concern was to manage and hold the chips of paint in place while the old sewing was removed, which would then allow us to turn the flag over and apply adhesive-coated Stabiltex to the reverse. We decided to use a remoistenable tissue facing, which would involve the application of a wet facing to the edges of the painted areas of the flag. We therefore needed to find a way to prevent water from wicking into the silk and causing tidelines. Molten CDD was used to form a barrier along the edge of the painted silk using an electric kistka (a tool used to decorate traditional Ukrainian Easter eggs). This method was chosen following a conversation with Claudia Iannuccelli at the Boston Museum of Fine Arts, who had recently used CDD to block out fugitive embroidery threads in a sampler prior to cleaning it on a suction table (Iannuccelli 2003). Also, we were aware that an ex-colleague of ours, Yadin Larochette, had been experimenting with CDD at the Winterthur Museum, where she had used it to coat an indigo-dyed embroidered monogram on a napkin so that she could use a reducing bleach to remove stains in the linen (Larochette 2004). The treatment of the flag was presented at the North American Textile Conservation Conference in 2003 (Hackett and Szuhay 2003) and we received considerable feedback from the textile conservators present that CDD would be a useful tool for a variety of applications. In the thirteen years since the treatment of the flag, I have had occasion to use CDD many times and I have come to think of it as having three major functions for the textile conservator: to contain the fugitive, to protect the ephemeral and to confine the useful.

Figure 1 Early 18th-century crib quilt (V&A 1564-1902), before treatment. Photo © Victoria and Albert Museum.

Figure 2 Early 18th-century crib quilt (V&A 1564-1902). Applying CDD with an electric kistka to coat the dark brown embroidery threads. Photo © Victoria and Albert Museum.

2 Containing the fugitive

CDD has proved to be a useful tool to prevent fugitive dyes from running and causing staining during aqueous cleaning, both in aqueous cleaning by submerging in a bath and during localised cleaning on a suction table. Typically, the dyes are found in applied decorations such as embroidery, but this technique has also been used to prevent unstable printed dyes from running into surrounding fabric and causing tidelines.

2.1 The conservation of an early 18th-century crib quilt

A small, early 18th-century whole-cloth quilt (V&A 1564-1902) was selected for inclusion in the V&A's exhibition 'Quilts 1700–2010'. This white linen quilt is dated 1703 but it is likely that the polychrome silk embroidery was added later in the 18th century. For many years this quilt had been mounted onto a wooden board, with the sides of the quilt turned to the back of the board and nailed in place. This had resulted in brown discoloration down each side of the quilt and all over the reverse. The linen was brittle and acidic. Brown staining in the linen surrounding the embroidered decoration indicated that the brown silk embroidery thread used to outline the entire embroidery design had run in the past (Figure 1). Testing confirmed that the dye was still fugitive and ran when wet. The condition of the ground fabric was of sufficient concern to risk aqueous cleaning the quilt to reduce the acidity of the linen. As a result, the decision was made to coat the brown embroidery with CDD to facilitate aqueous treatment.

A facsimile of one part of the embroidery was made in order to try various interchangeable nibs in a new electric kistka to see which gave the best coverage. This was done to ensure that it was possible to work quickly enough to coat the embroidery with sufficient CDD to prevent water penetration. The finest nib on the kistka was chosen as this gave the most precise coverage, though this resulted in a slower coating process overall. The multi-layered nature of the quilt meant that it was impossible to coat the reverse side of the embroidery as this was hidden by the quilt's lining; however the embroidery had been done in satin stitch so that around 90% of the embroidery threads were on the face of the quilt. The coating of all the brown embroidery threads on the quilt took five hours (Figure 2). The quilt was wet cleaned the following morning in a 0.2% solution of Dehypon LS 45 with 0.1 g/L of sodium carboxymethyl cellulose added, and then rinsed with successive baths of deionised water. The quilt was pinned out onto a padded table to dry while covered with a layer of cotton muslin to aid in stain reduction. Electric fans were used to speed the drying process. After treatment the quilt's appearance was very much improved and no new dye loss

Figure 3 Early 18th-century crib quilt (V&A 1564-1902), after treatment. Photo © Victoria and Albert Museum.

was observed (Figure 3). We did however note that the CDD took several weeks to sublime fully, the rate of sublimation being very much dependent on the thickness of application and the material coated. During my previous experience of using CDD in the thin silk of the Civil War flag, we had noted a sublimation time of 3 to 4 days. These observations have been confirmed in a study by Sarah Confer (2006), which indicated that sublimation was quickest from linen and silk, followed by cotton and Dacron, but that it appeared to have something of an affinity for wool. She discovered that half of the mass of the cyclododecane in the test samples had sublimed within 24 hours of application, and that it was entirely sublimed after 9 days, even on wool. Most importantly, she could not detect any traces of CDD after sublimation with flame ionisation detection gas chromatography (GC–FID) or Fourier-transform infrared spectroscopy (FTIR).

2.2 The wet cleaning of a 19th-century embroidered Turkish towel

In 2012, two 19th-century embroidered Turkish towels were selected for inclusion in the permanent display in the Jameel Gallery of Islamic Art at the V&A. While the first towel proved straightforward to wet clean, the second (V&A T.460-1950) contained a dark pink silk embroidery thread that ran when wet.

Figure 4 Turkish embroidered towel, 1830–1870 (V&A T.460-1950). After treatment, detail of one end of the towel and the embroidery. Photo © Victoria and Albert Museum.

As this colour was only present in small amounts in the decorated borders at each end of the towel, it proved a simple matter to coat both the back and front of the pink embroidery with molten CDD prior to aqueous cleaning. Testing also suggested that the embroidery ran less in water modified to a low pH and so the towel was wet cleaned with deionised water modified with acetic acid to pH 4.5, followed by successive baths and rinsing with deionised water. The towel was pinned to a padded board during drying and electric fans were used to speed the drying process. After cleaning, the background colour was lighter and there was no sign of dye running (Figure 4). However, old stains in the ground fabric remain.

This system for aqueous cleaning embroidered textiles with fugitive dyes has now become a commonplace treatment at the V&A, with the only caveat being the size of the textile and the amount of fugitive embroidery to be coated.

3 Protecting the ephemeral

As well as preventing dyes from running and causing staining, we also use CDD to protect ephemeral marks such as import stamps, maker's signatures, accession numbers and paper labels when wet-cleaning textiles. This approach is common in paper conservation and was first published in textile conservation literature in the description of the cross-disciplinary treatment of a Japanese ceremonial doll (Kaplan 2002).

Figure 5 Block-printed cotton muslin with a design of lily-of-the-valley, 1799 (V&A T.113b-1925). Before treatment; the muslin is folded and pinned to a fabric-covered wooden board next to another example of printed cotton from the same era. Photo © Victoria and Albert Museum.

3.1 The wet cleaning of an 18th-century printed cotton muslin

When the gallery housing a permanent display of fashionable dress at the V&A was renovated in 2011, a complete redisplay of the collection was planned to include flat textiles, accessories, dolls, underwear and ephemera, to better explain the context of the history of fashion. A piece of printed cotton muslin was included in the 18th-century dress case to illustrate the shift to cotton as the most desirable material for fashion after centuries of silk and wool. One particular printed muslin (V&A T.113b-1925) was particularly interesting as it included the end of the roll where the manufacturers' stamps and the customs import stamp could still be seen. These stamps tell the story of how plain cotton muslins were imported from India into England, where they would be block printed and then sold on to the consumer. This particular muslin was printed all over with a design of lily-of-the-valley in around 1799, when the importers, 'Messrs. Brown, Rogers and Co, Wholesale Linen Drapers', were in business in Cheapside, London. This muslin had for many years been displayed in a glazed frame in one of the pull-out racks in the old textile galleries of the V&A and as a consequence had been folded up and pinned to a wooden board to make it fit within the rack (Figure 5). It was clearly important to wet clean the muslin in order to remove the sharp creases and to reduce the acidity within the cotton, which was visibly yellowed. However, it was equally important not to lose the stamps and signatures at the end of the muslin, some of which were slightly fugitive when tested with water. The stamps were coated with CDD and then the muslin was wet cleaned with a 2% solution of Hostapon T in deionised water followed by rinsing with deionised water. The appearance of the muslin was vastly improved by aqueous cleaning and it is now displayed in the gallery on a hanging bar to emphasise the lightness and transparency of the material (Figure 6).

Figure 6 Block-printed cotton muslin with a design of lily-of-the-valley, 1799 (V&A T.113b-1925). After treatment, on display in the fashion gallery at the V&A. Photo: © Victoria and Albert Museum.

4 Confining the useful

More recently, we have begun to use cyclododecane in conjunction with other cleaning systems as a way of confining a particular chemical to a specific part of a textile, usually in order to prevent the formation of tidelines. We have used CDD as a way of containing the spread of liquids held in gels and poultices and as a way of preventing chemicals from wicking along threads by capillary action, taking them into areas where they are not wanted.

4.1 Corrosion removal from brass decoration on 19th-century Turkish shoes

In June 2015, the V&A opened a major exhibition of shoes within the fashion gallery titled 'Shoes: Pleasure and Pain'. The display included over 250 pairs of shoes from around the world, spanning many centuries. A pair of Turkish shoes (V&A T.181 and a -1912) from the dress of a Jewish woman was included in part of the display on how shoes can reveal status and allegiance. These red leather shoes are trimmed at the toe with silk pom-poms and embroidery made from brass strips wound around cotton threads (Figures 7 and 8). The brass decoration on the shoes was very tarnished with a heavy build-up of a green corrosion product, probably copper or zinc carboxylates, which are common corrosion products found on leather items trimmed with brass. The metal carboxylates can be reduced with a combination of mechanical action and solvent cleaning in a mixture of 90% white spirits and 10% ethanol, as described in the treatment of the brass beads on a leather belt in the McCord museum (Werner *et al.* 2012). The problem with cleaning the brass strips on the shoes was that the brass had been wrapped around cotton threads to form a crude bullion and any solvent applied to the brass would be wicked down the cotton cord and into the leather of shoe. Ethanol can be disruptive to the oils and tannins in leather and this was to be avoided if possible. However, a study by Myriam Lavoie (2006) confirmed that molten CDD is an effective barrier against a variety of cleaning solutions commonly used to remove cuprous corrosion when cleaning metal decorations on leather, and that the CDD has no lasting effect on the appearance of the leather after treatment. A dot of molten cyclododecane applied at the end of each of the cotton threads holding the brass strips prevented the solvent from being drawn down into the leather by capillary action. The brass decoration on the shoes was cleaned in the following way. Strips of Melinex were cut to fit behind the brass decoration and a strip of blotting paper was fitted between the Melinex and the brass decoration. The brass was then brushed with a dry brush followed by a brush that had been dipped in the solvent mixture. The solvent and dissolved corrosion product was absorbed by the blotting paper, which was changed after each application, and the process was repeated until no more green corrosion product was noted on the blotter (Figure 9). This cleaning system proved very effective and no solvent was observed wicking into the leather.

4.2 Stain reduction on the silk counterpane of an 18th-century day bed

The Jacob Bed (V&A 8459-1863) is a significant piece of French furniture by Georges Jacob made in Paris in around 1780. The carved and gilded beech wood day bed retains its original silk damask hangings.

Figure 7 Turkish shoe, 19th century (V&A T.181 and a-1912). Detail of the brass decoration at the toe before treatment. Photo © Victoria and Albert Museum.

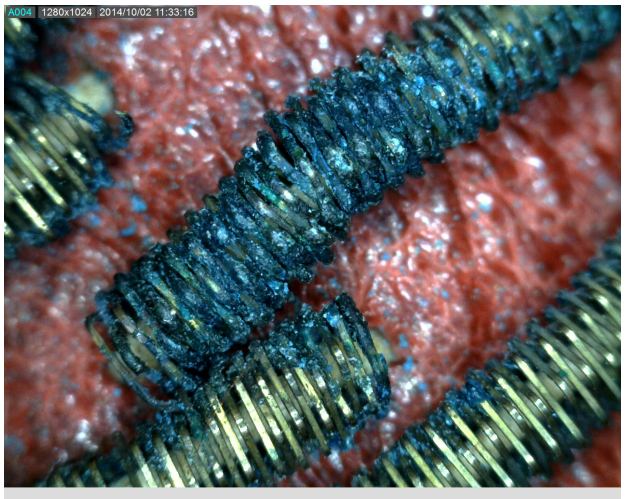

Figure 8 Turkish shoe, 19th century (V&A T.181 and a-1912). Dino-Lite digital photomicrograph showing corrosion on the brass strips (×35 magnification). Photo: © Victoria and Albert Museum.

Figure 9 Turkish shoe, 19th century (V&A T.181 and a-1912). Detail of the cleaning process, where the corrosion is reduced by brushing with a solvent mixture of 90% white spirit and 10% ethanol. The corrosion product is absorbed by strips of blotting paper. Photo © Victoria and Albert Museum.

Figure 10 Counterpane of the Jacob bed (V&A 8459-1863). Detail of the stain on the silk before treatment. Photo © Victoria and Albert Museum.

The recent redevelopment of the European galleries, which opened in December 2015, allowed the bed to be removed from display, thoroughly documented and conserved for the first time since the galleries were last renovated in the 1970s. Apart from the usual weakness, tears and losses in the silk throughout the bed upholstery and drapery, there was a significant and disfiguring stain on the top of the bed's counterpane (Figure 10). This stain appeared to be oily in nature and responded well when tested with the enzyme lipase from Candida rugosa type VII. It was felt that a gel poultice containing this lipase might prove effective in reducing the stain, if the moisture from the gel could be contained and the residues rinsed away without forming a disfiguring tideline. Soiling and staining mobilised by an aqueous cleaning system tends to travel along the fibres of the textile being cleaned, forming new stains at the wet/dry interface. This type of tideline staining is not only disfiguring but can also form an area of weakness in the textile.

The Jacob bed counterpane is a two-layer structure with a silk damask top and a linen lining. In order to better predict how the counterpane would behave with the gel and subsequent rinsing, a facsimile textile was made, to test the best way of delivering the cleaning system. In order to contain moisture from both the gel and the rinsing it was found that CDD had to be applied to both sides of the facsimile textile and that a template of the stain would be needed in order to accurately apply the CDD to the lining where it would be most effective.

The stain on the counterpane was treated in the following way. A solution was made with 100 ml of deionised water and 0.5 g of tris(hydroxymethyl)aminomethane (TRIS). The solution was adjusted to pH8.5 with citric acid and then gelled with 2 g of methylcellulose. The enzyme was added to the gel by dissolving 0.5 g of lipase type VII in a few drops of water and mixing it with the gel, making sure not to create air bubbles that would denature the enzyme and reduce its working strength. A line of CDD was drawn around the stain on both sides of the counterpane. Gel was applied to the stained area and left in place for 15 minutes. The gel was then removed with a spatula and the stained area was rinsed on a suction table. A layer of cotton muslin was placed below the counterpane on the suction table and blotters were used on the upper surface to remove the soiling and staining (Figures 11 and 12). The appearance of the stain was improved, though traces remain in the silk. The damaged area of silk associated with the stain was covered with a protective layer of dyed nylon bobbin net.

Figure 11 Counterpane of the Jacob bed (V&A 8459-1863). Detail of the stain on the silk during treatment. The stain has been surrounded by a ring of CDD and is being rinsed with deionised water while on a suction table. Photo © Victoria and Albert Museum.

Figure 12 Counterpane of the Jacob bed (V&A 8459-1863). Detail of the stain on the silk after treatment. Photo © Victoria and Albert Museum.

5 The limitations of cyclododecane in textile conservation

The major drawback when using CDD in textile treatments is the time needed to apply it accurately. For example, we recently treated a Greek door curtain (V&A T.652-1950) made of heavily embroidered linen that had been on display in a heavy wooden frame for very many years. When it was selected to be part of the new European gallery display, our first thought was to wet clean it and remount it onto a padded board. However, the green embroidery threads used extensively throughout the design ran when tested. This

embroidery is 218 cm high and 109 cm wide, and so CDD was considered and then dismissed as simply being too time consuming: it would have taken at least a week for two people to accurately mask all of the green threads, at which point there would have been some question about how effective the CDD would have been as a barrier. After discussion, the embroidery was wet cleaned and, although some dye loss was noted in the early part of the washing cycle, none was noted in later rinsing. The embroidery was pinned out to dry with close contact muslin cloths and rapidly dried with hairdryers to minimise the risk of bleeding. In this case no dye bleeding was noted and the appearance of the textile was improved.

Similarly, CDD was considered for the treatment of a wedding dress heavily embellished with artificial pearls. The wedding dress (T.78:1-2013) was made by Isobel for the wedding of Anne Molineux in 1953 and was acquired for inclusion in the V&A's exhibition 'Wedding Dresses 1775–2014'. The silk and machine-made lace dress was yellowed and did not present the designer's original intent of a white wedding gown. The artificial pearls covering the dress were made from hand-blown glass balls coated on the inside with a pearlescent lacquer and then filled with a layer of wax to give weight to the 'pearl'. Unfortunately, the binder used for the pearlescent lacquer was found to be water soluble and was identified using FTIR as hide glue (Lee 2014). Luckily, the wax coating gave protection to the interior of the pearl, but the wax did not cover the area at the 'neck' of the pearl. As the dress was covered in several hundred pearls cyclododecane was dismissed and the dress was given an abbreviated wash with a short rinse time using a new non-ionic surfactant, Dehypon LS 54. The results were good and, while a small amount of lacquer was lost at each side of each pearl, the overall effect was preserved (Figure 13).

Figure 13 Wedding dress, 1953 (V&A T.78:1, 2-2013), after treatment. Photo © Victoria and Albert Museum.

6 Conclusions

Cyclododecane is a useful tool for the textile conservator. It is an effective barrier for protecting water-sensitive or fugitive materials during wet treatments. It appears to sublime fully from most substrates, or at least below detectable limits, and it does not alter the long-term appearance of textiles or leather. Further investigation into the possible long-term effects of CDD residues would be useful to confirm that it is a benign presence even after sublimation.

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Biography

Joanne Hackett joined the V&A in 2006 as a Senior Textile Conservator and has been the Head of Textiles and Fashion conservation since 2015. Before joining the V&A, she worked at the Indianapolis Museum of Art and the Fine Arts Museums of San Francisco. She received an MS in Art Conservation from the Winterthur/University of Delaware Programme in Art Conservation with a specialism in textile conservation in 1998. She has an interest in three-dimensional and composite textiles and has personal responsibility for the textiles in the fashion gallery of the V&A. She was lead conservator for the exhibitions 'Shoes: Pleasure and Pain', 'Bowie Is', 'Quilts: 1700–2010' and 'Balenciaga: Shaping Fashion'. She is an accredited member of the Institute of Conservation and a Fellow of the American Institute of Conservation.

References

Confer, S. (2006), *Cyclododecane: an examination of the rate of sublimation from various textile substrates*, Master's thesis, Queen's University, Canada.

Hackett, J. and Szuhay, B. (2003), 'Facing the future: the use of cyclododecane and re-moistenable tissue paper in the conservation of a painted silk flag', in J. Vuori, ed., *Tales in the Textile. The Conservation of Flags and Other Symbolic Textiles. Preprints of the North American Textile Conservation Conference, Albany, New York*, NATCC, Waterford, NY, pp. 167–176.

Iannuccelli, C.P. (2003). Textile Conservation, Boston Museum of Fine Art. Personal Communication.

Kaplan, L. (2002), 'Conservation through investigation: uncovering the story of a Japanese ceremonial doll', in *The Textile Specialty Group Postprints. American Institute for Conservation of Historic and Artistic Works Annual Meeting (30) Miami, Florida*, pp. 105–118.

Larochette, Y. (2004), 'Determining the efficacy of cylododecane as a barrier for a reduction bleaching treatment of a silk embroidered linen napkin', in *The Textile Specialty Group Postprints. American Institute for Conservation of Historic and Artistic Works Annual Meeting (32) Washington D. C.*, pp. 1–10.

Lavoie, M. (2006), *Cyclododecane as a temporary sealing agent on vegetable-tanned leather during chemical cleaning of associated metal components*, Master's thesis, Queen's University, Canada.

Lee, R. (2014), 'Testing non-ionic detergent dehypon LS54: Part one', Unpublished.

Werner, U., Selwyn, L.S., Stone, T., McKinnon, W.R., MacKay, A. and Grant, T. (2012), 'The removal of metal soaps from brass beads on a leather belt', *Studies in Conservation* **57**(1), pp. 3–20.